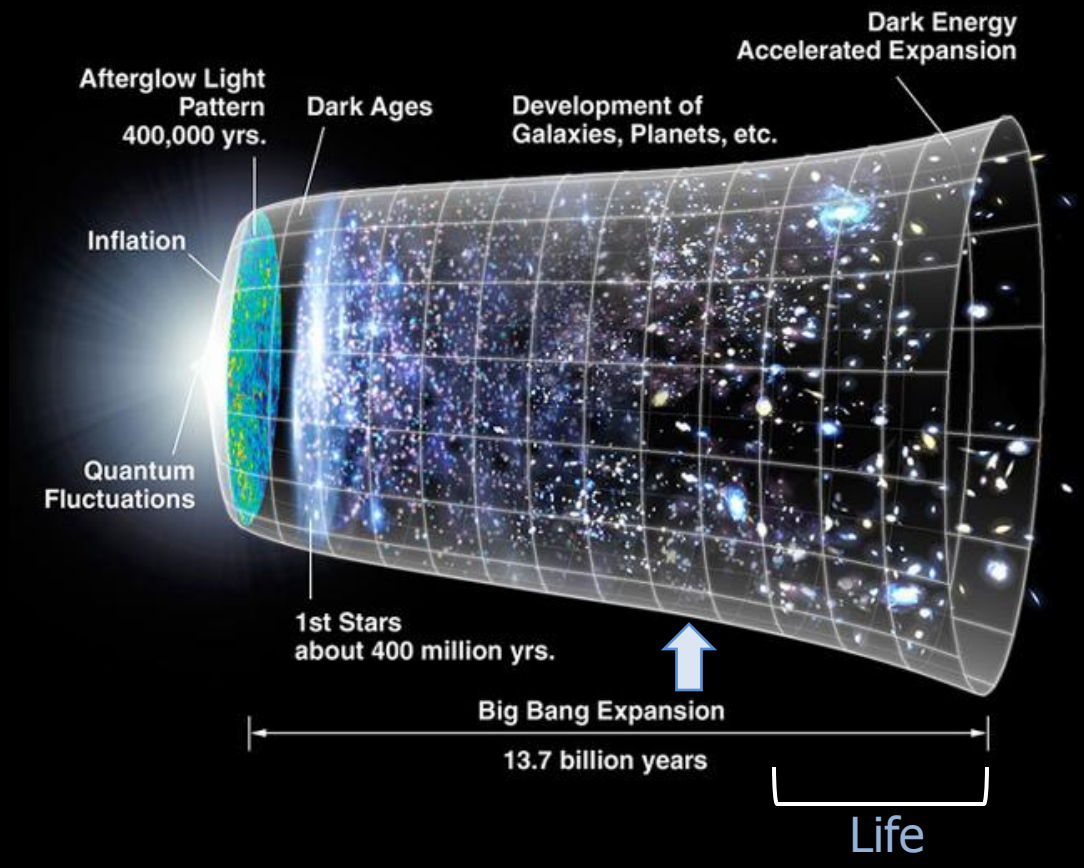
& The Origin of Life

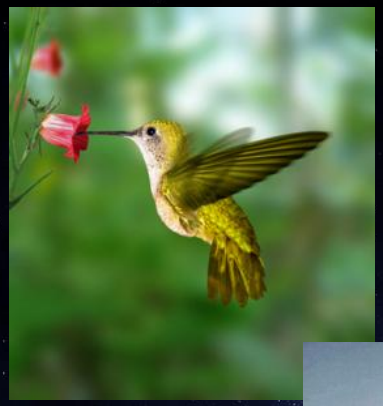
Physics Theory of Creation

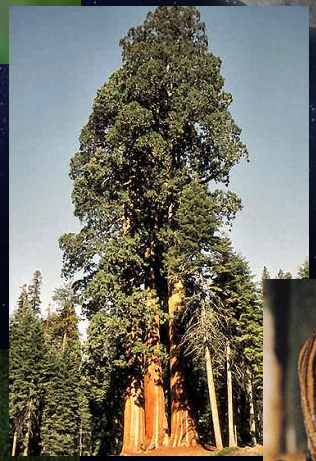


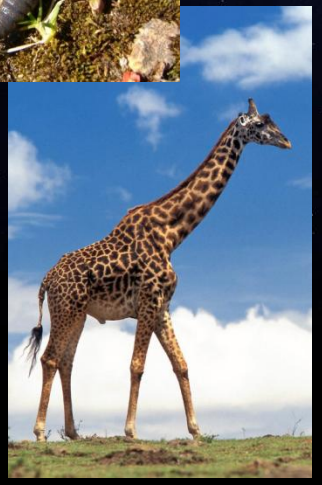
Earth ~ 4 billion years ago

Lifeless

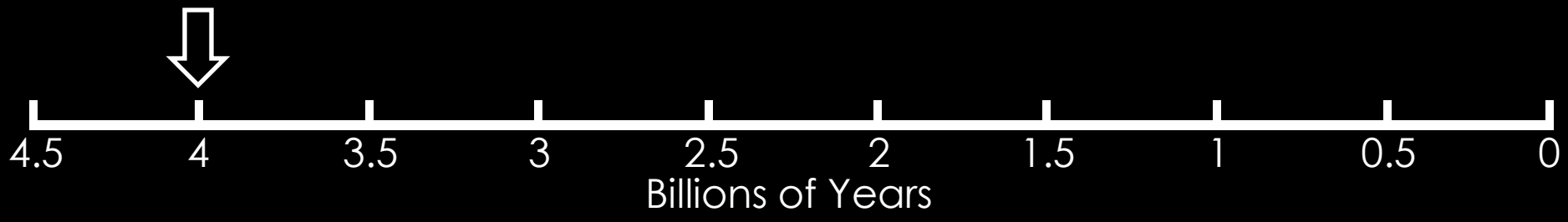
Earth ~ 4 billion years later







Origin of Life – Early Earth



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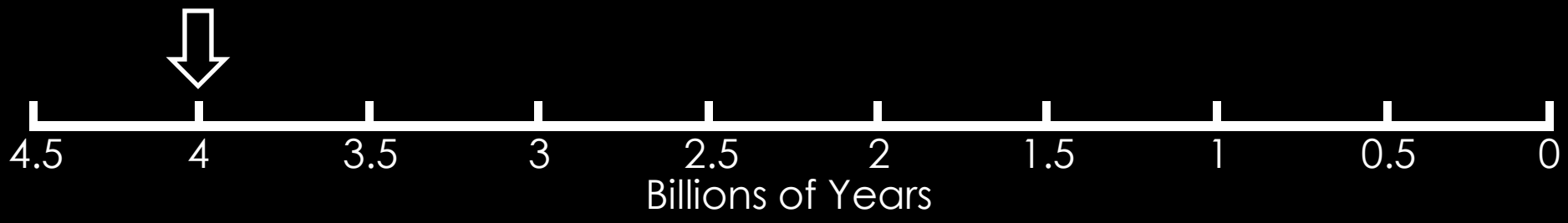
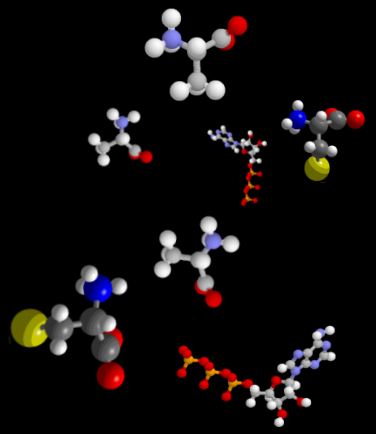


Origin of Life – Organic Soup

Simple Organic Acids

Simple Chains

Complex Chains

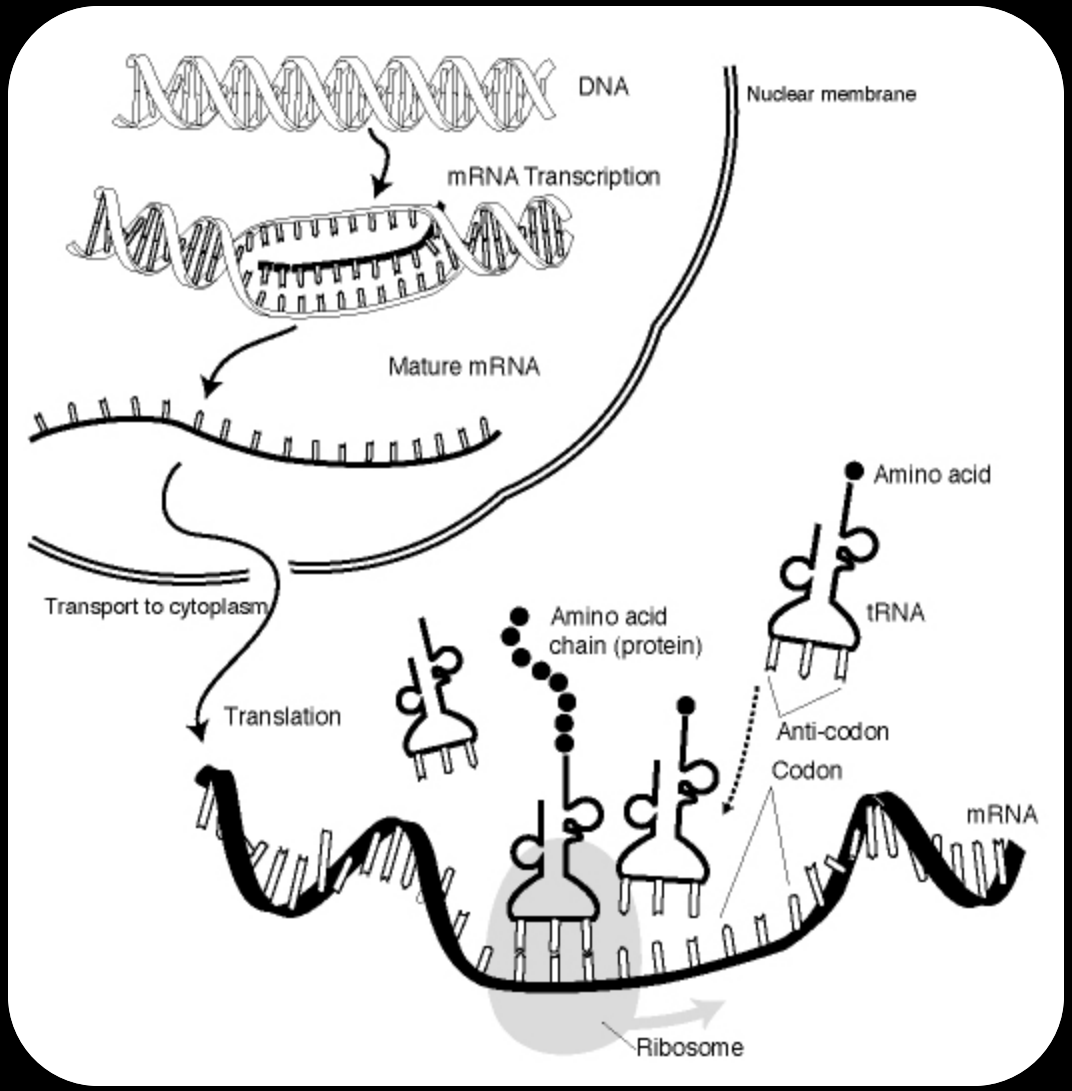


RNA

4.5 4 3.5 3 2.5 2 1.5 1 0.5 0

Billions of Years

Does everyone know gene expression?



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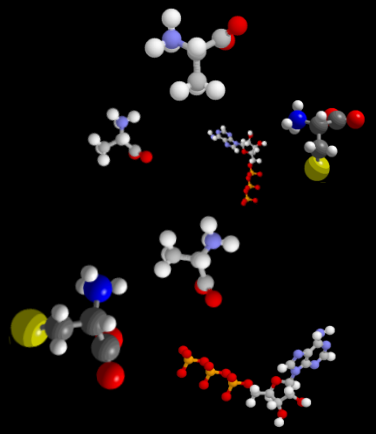


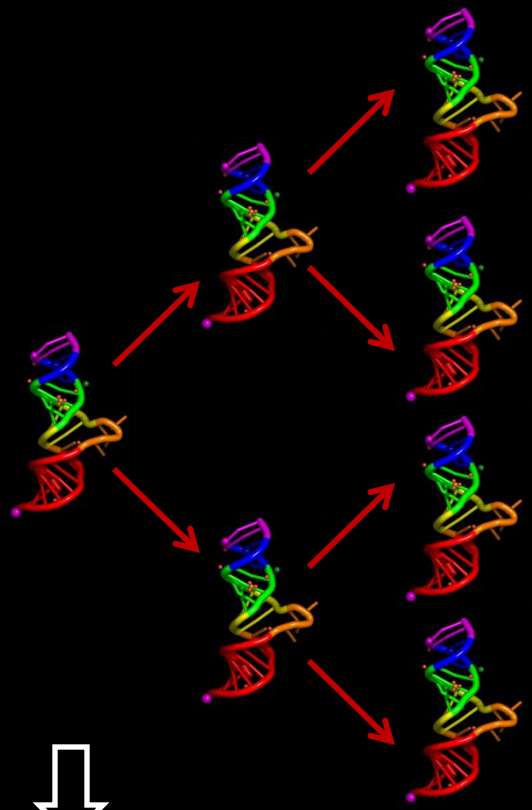
RNA

4.5 4 3.5 3 2.5 2 1.5 1 0.5 0

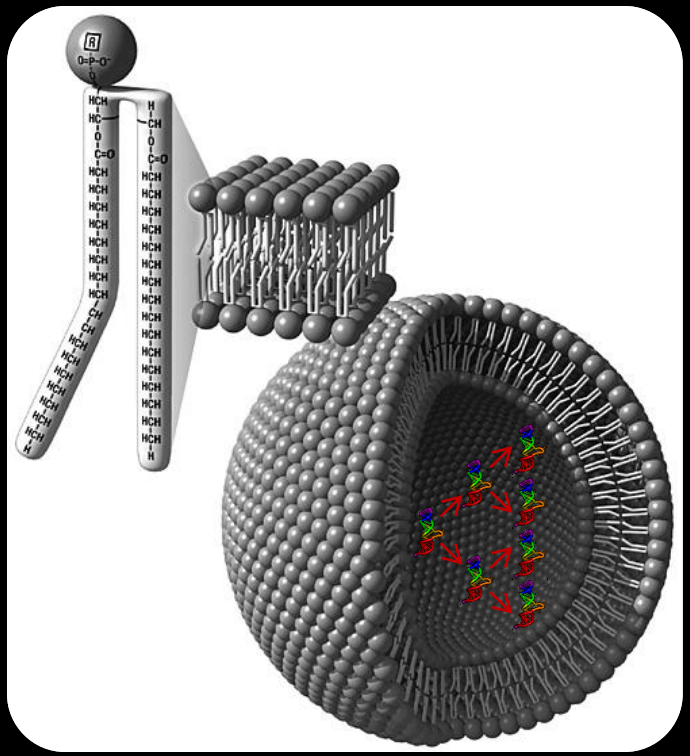
Billions of Years

Origin of Life – RNA World

Self Replication RNA



Lipid Vesicles



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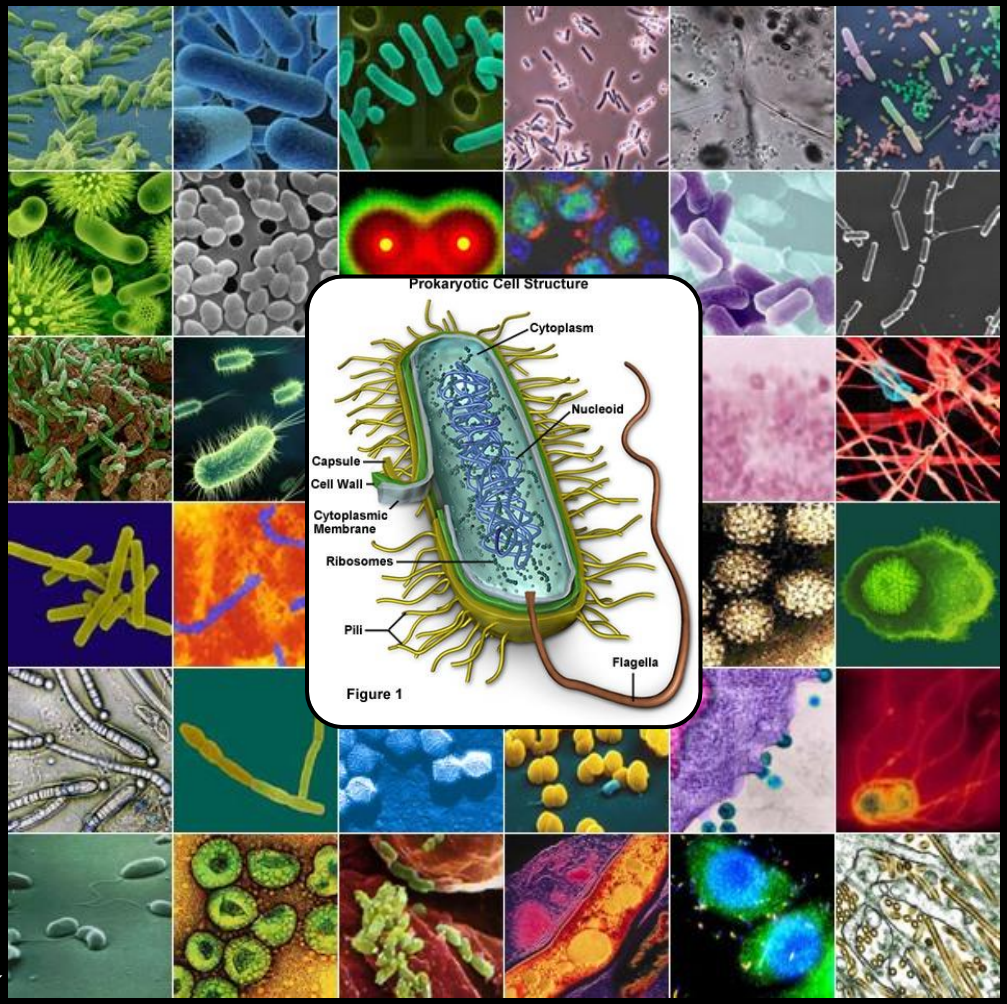
Billions of Years

Origins of Life – Bacterial world



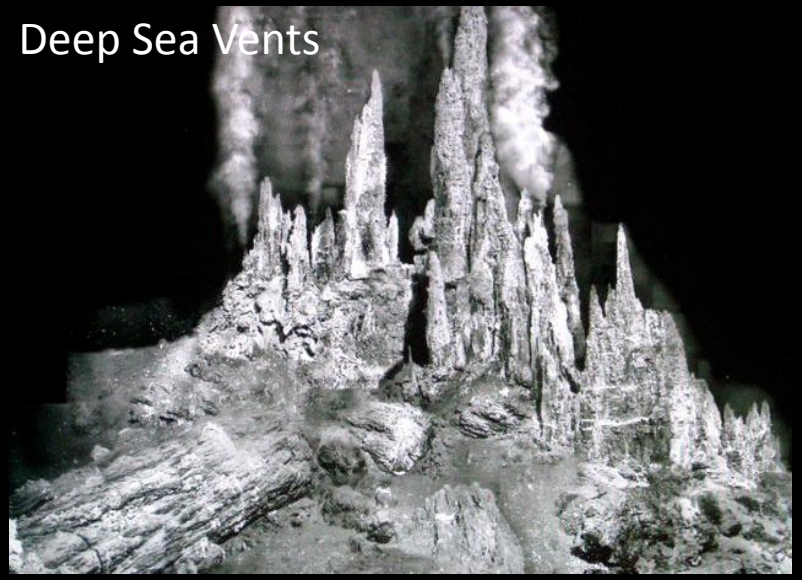
4.5 4 3.5 3 2.5 2 1.5 1 0.5 0

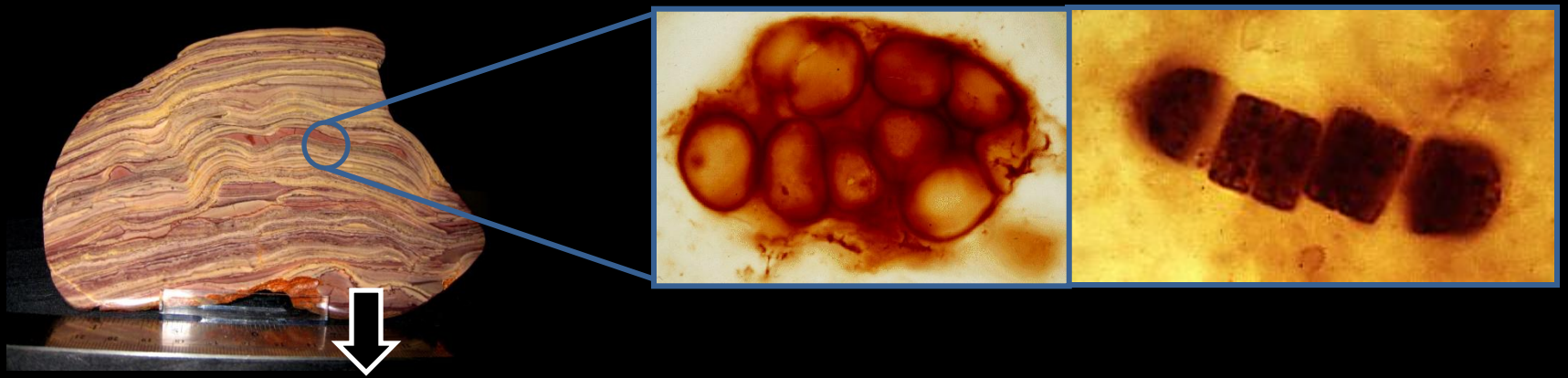
Billions of Years

Origins of Life - First Ecosystems

Marine Environments

Deep Sea Vents





4.5 4 3.5 3 2.5 2 1.5 1 0.5 0

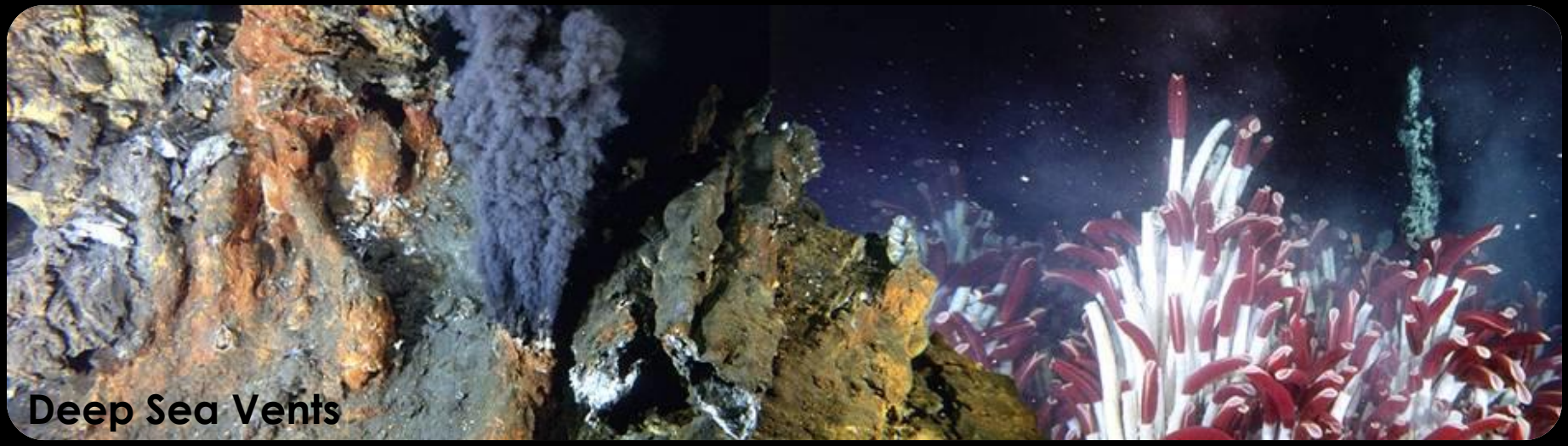
Billions of Years

Origins of Life – Modern Analogues

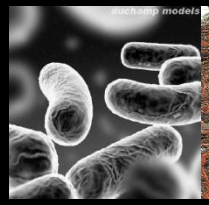
Microbial mats relegated to extreme environments

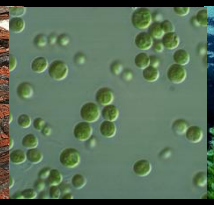
Hot springs, salty lakes, deserts

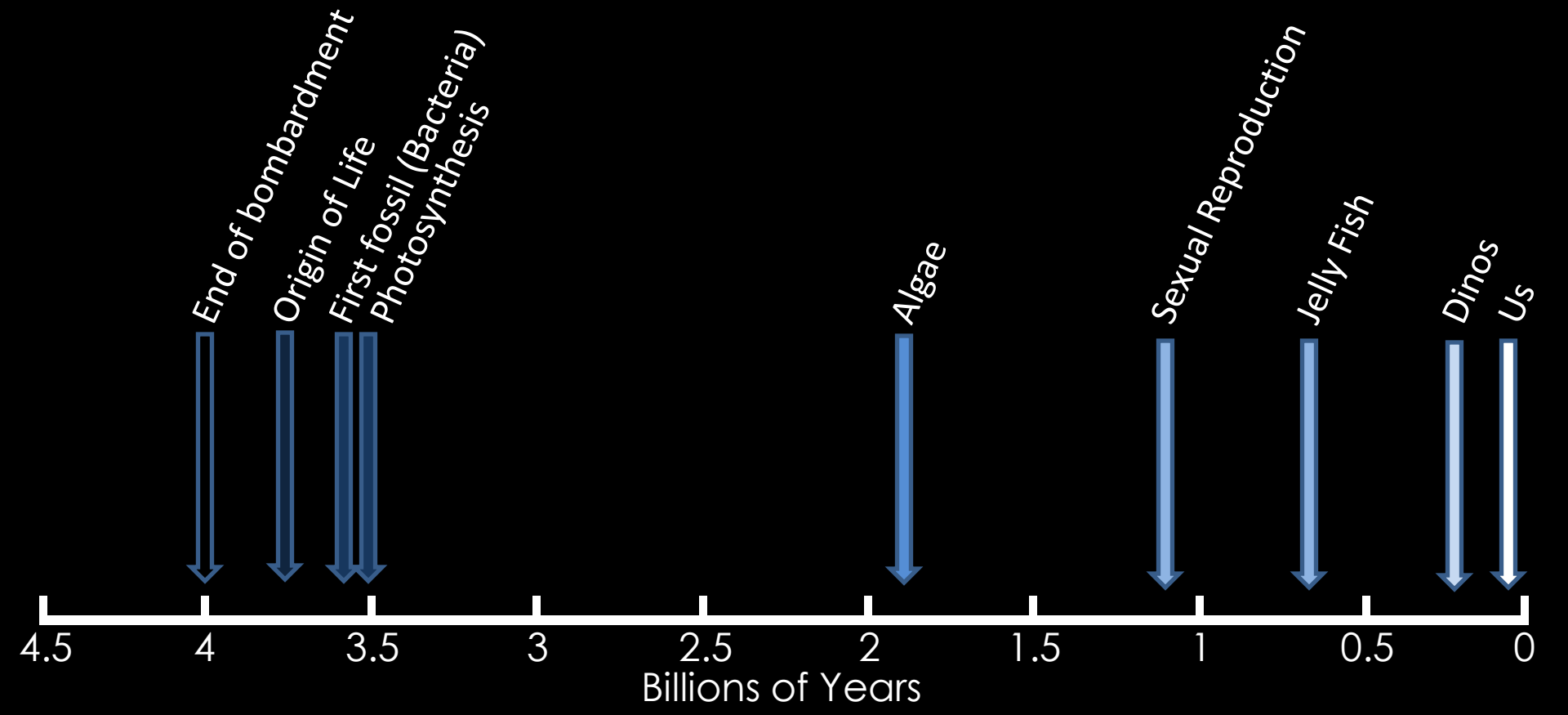
No or low grazing

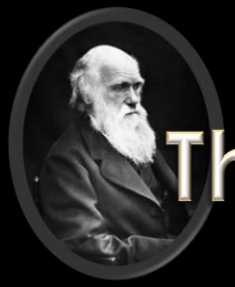


Life's Greatest Hits

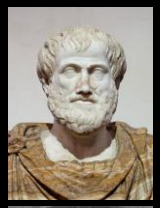








The Road to Darwinian Evolution



Aristotle (384-322 B.C.)
Spontaneous generation

John Ray (1627-1705 A.D.)
Categorization of genera and species – inference that similar organisms are connected in some fashion

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Generation of new life by creating hybrids – implied inheritance

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Suggested that species evolve. Modifications made over one lifetime are pasted to descendants

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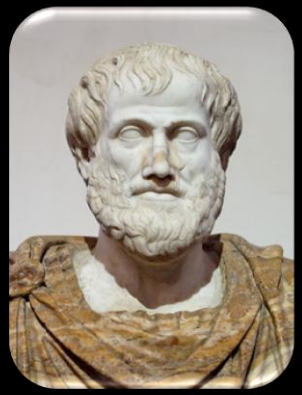
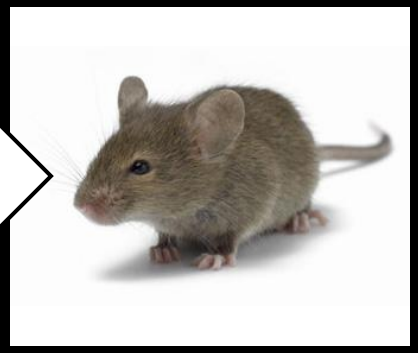
Finally disproved spontaneous generation of life

Spontaneous Generation



Aristotle -
Animated life comes from inanimate things

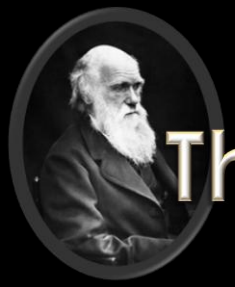
Moldy Grain



Rocks & Mud

Rotten Meat

Fire



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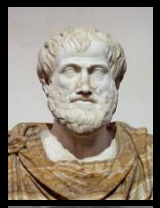

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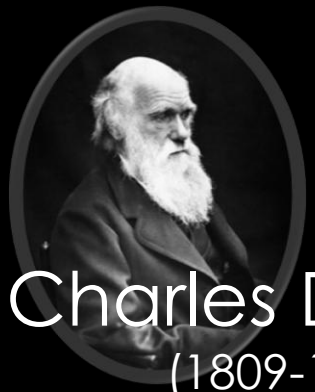
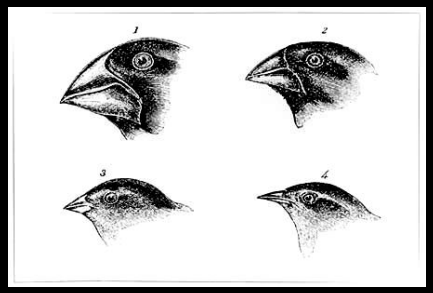


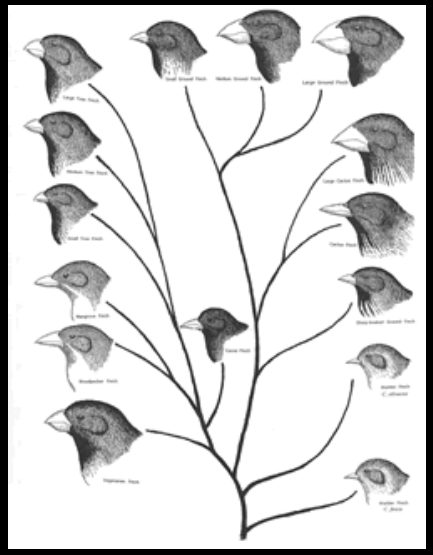
Charles Darwin
(1809-1882 A.D.)

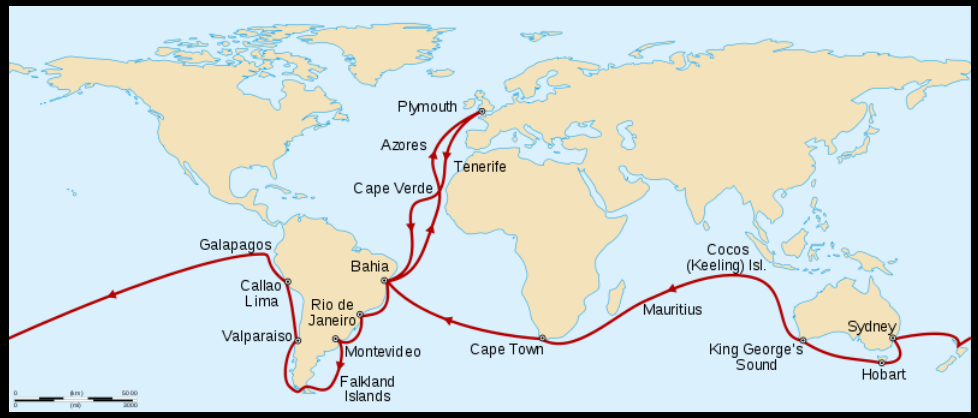
5 year boat tour

Common ancestor

Evolution of species driven by natural selection



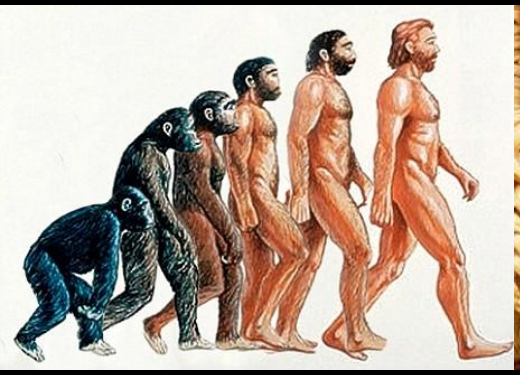


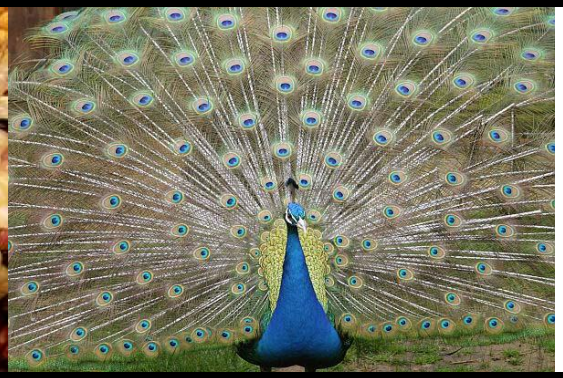
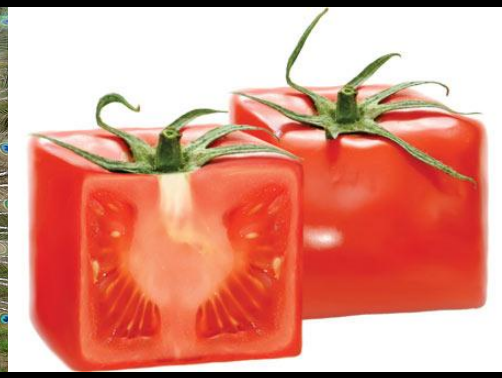


Evolution

The change in inherited traits of a population of organisms over successive generations

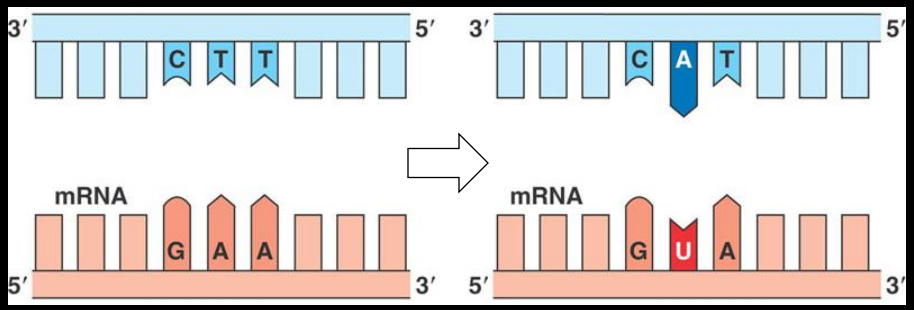
Mutation – Genetic diversity – Inheritance – Natural Selection



Mutation

Modification of the genetic code



Glutamate Valine

Silent – not transcribed or wobble region

Expressed – leads to a change in protein function and thus physical trait

Mutation

5’ NASA is hiding aliens on this base. 3’

NASA is hyding aliens on this base.

Silent point mutation

NASA as hiding aliens on this base.

Deleterious point mutation

NASA ip shidin galien so nthi sbase.

Deleterious point mutation with a frame shift

NASA is hiding olives on this base.

Multiple mutations leading to new function

Mutation

Most mutations are deleterious
- Loss of function
- Death

Rates of Mutation
- Humans:
- 2.5 x 10^{-8} mutations/nucleotide/generation
- 175 mutations per generation
- 3 million base pairs in human genome

Mutation rates can increase when organisms are stressed

Accumulation of slightly deleterious mutations
- Purged through sexual reproduction

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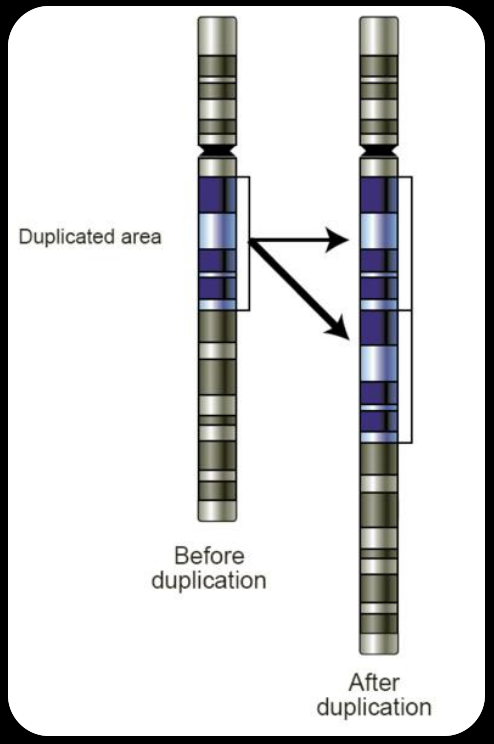
Mutagens

UV radiation
X-rays
Gamma rays
Ethidium Bromide
Air bags (Sodium azide)
Plastic (Benzene)
Viruses
Transcription errors
Hot Dogs (Nitrates)
Cooked food (heterocyclic amines)
Nalgene water bottles (bisphenol-A)
Smog
Cigarettes (benzo[a] pyrene)

Sun
Air
Food
People

Gene Duplication

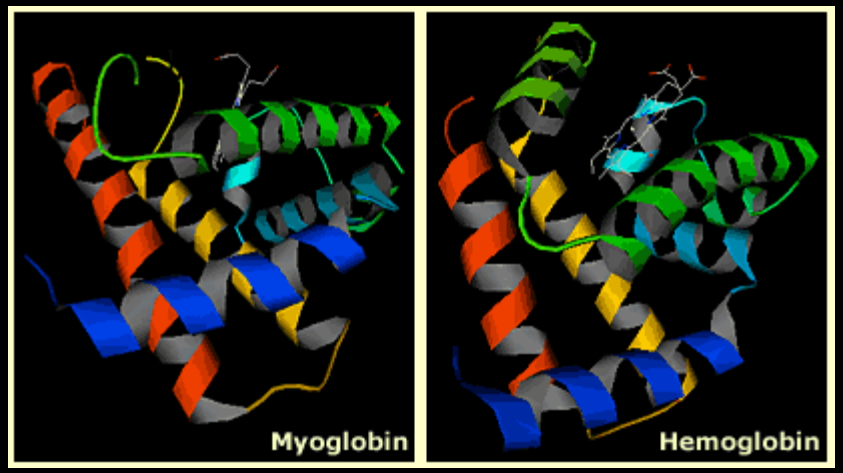


Major role in evolution

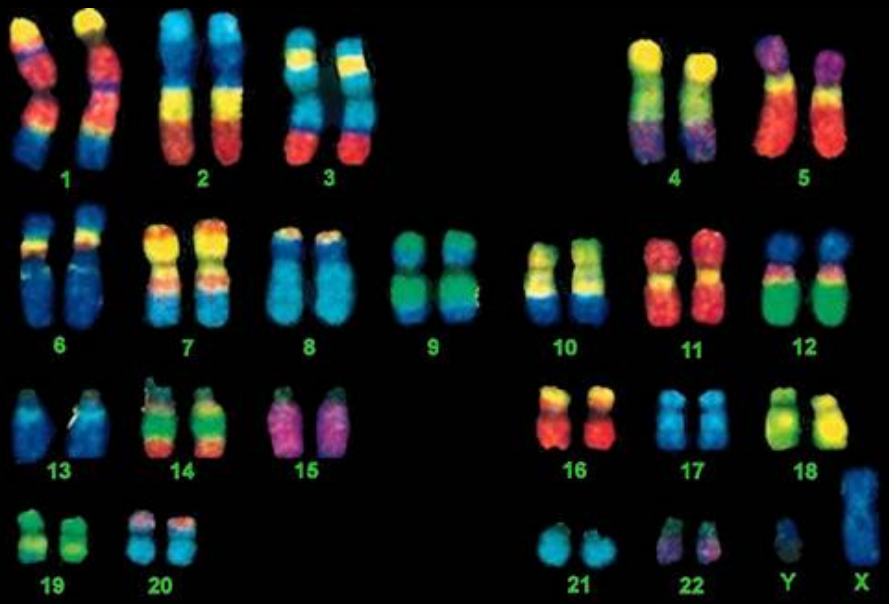
Greater gene expression – sometimes good, sometimes bad

Neutral – gene can accumulate mutations leading to a new function

1) Digestive enzyme in ice fish
2) Myoglobin and Haemoglobin



Alleles



Genome duplication

Two (or more) copies of the same gene but on separate chromosomes

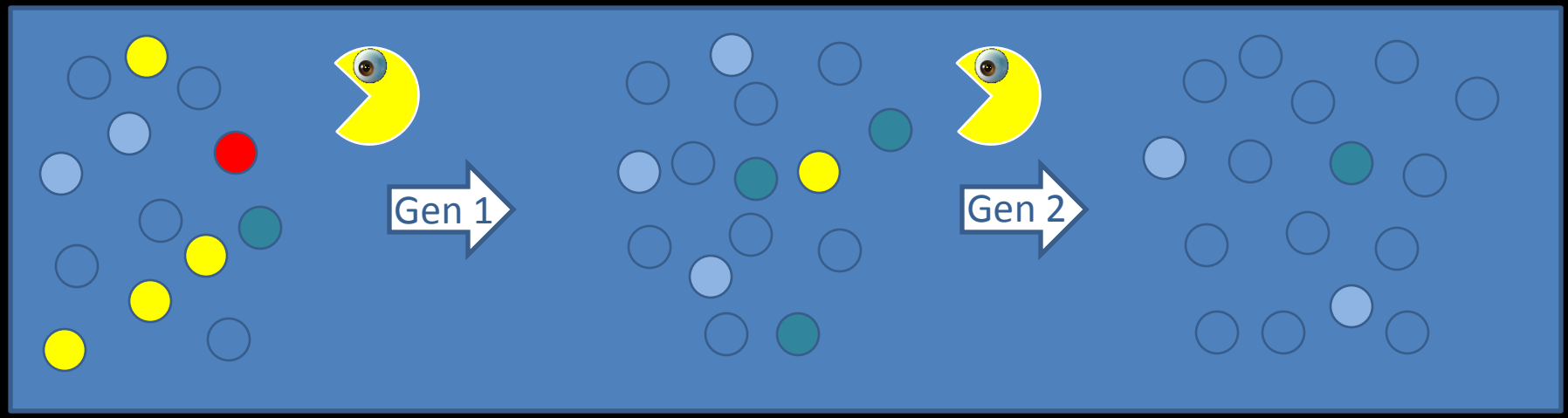
Increases diversity

Limits the effects of deleterious mutations – masked by gene copy

Polyploidy:
Triploids – Banana
Tetraploids – Tobacco
Hexaploid – Kiwi fruit
Octaploid - Strawberry

Selection

Evolutionary pressure that works over multiple generations to cause certain traits to become more prominent than others in a population



Selection

- Environmental Selection – Physical pressures from the environment (temperature, predation, water availability)
- Sexual Selection – mate selection
- Artificial Selection – Human interests

Evironmental Selection

Environmental Stress

Temperature
Food availability
Water availability
Sun availability

Predation or Grazing

Any environmental factor that prevents you from procreating

Global Climate Change

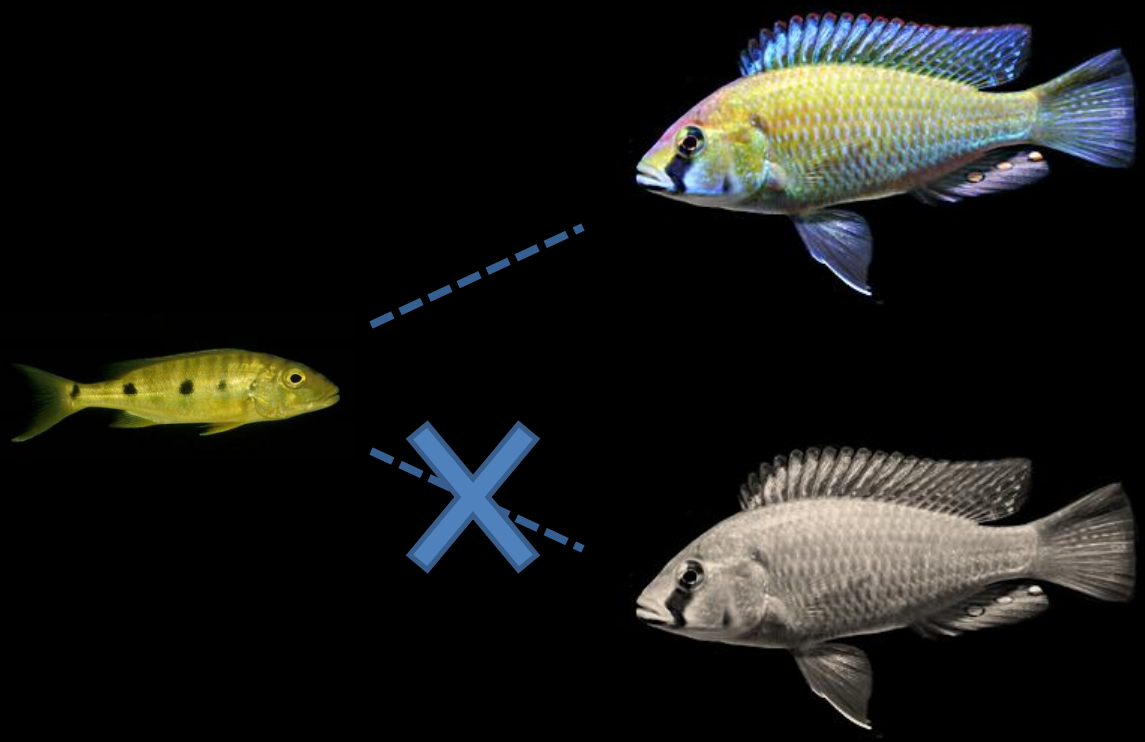
Rates of environmental change
vs.
Rates of evolution

Evolution:
Generation time
Genetic diversity
Expressed diversity (population size, clutch size)

Acclimation:
Dispersion
Mobility

Sexual Selection

♀ ♂



Sexual Selection

Sexual Selection

Physical modifications to attract mates

Physical modifications to compete for mates

Behavioral modifications to attract mates

INCREASE VISIBILITY TO PREDATORS

Selective Breeding

Natural selection is circumvented through human intervention

1. Humans breed organisms with traits beneficial to our needs

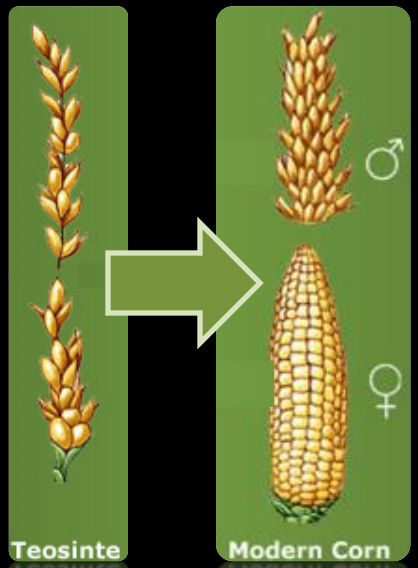
2. Humans prevent organisms of the same species with non-ideal traits from breeding

3. Modify environment to sustain new organism
   -remove predation, competition, provide resources

4. Called "Domestication"

Selective Breeding

Corn



Dogs

Selective Breeding

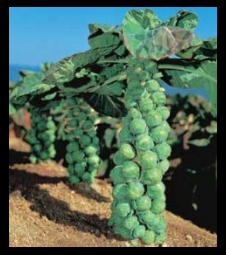
Kohlrami

Cauliflower

Cabbage

Broccoli

Kale



Brussel Sprouts

Chinese Broccoli

Brassica oleracea

Genetic Modification

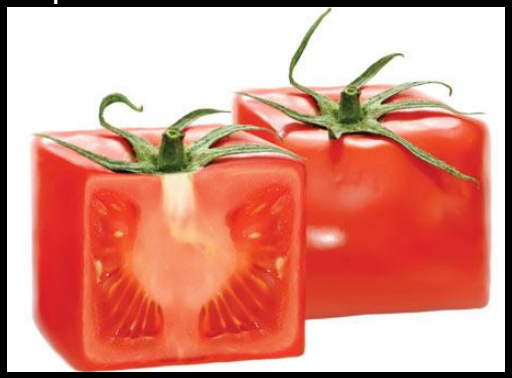
Transfer genes between organisms that can not be breed through conventional means

Gene addition or gene deletion

EnviroPig

GFP Mice

Square Tomato

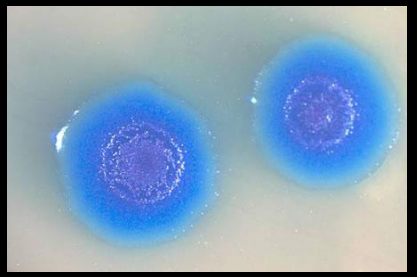


Creating New Life from Scratch

Create designer genomes and thus designer life to perform specific tasks

May 2010
Artificially generated a bacterial genome and integrated it into a bacterial host cell

J. Craig Venter INSTITUTE



Questions:
Is this different than selective breeding?

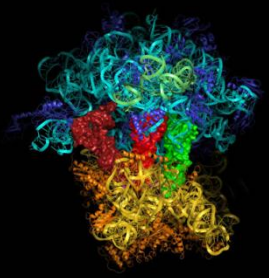
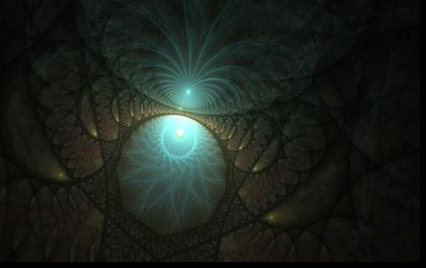
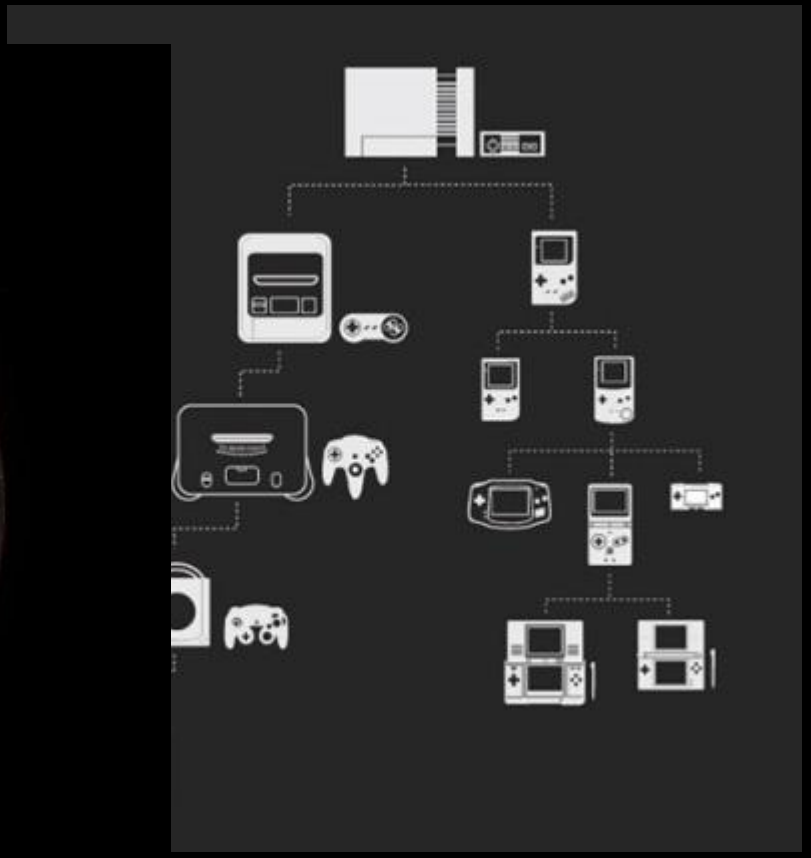
Is it moral to patent life?

What are the implications?

Future of life

As we move into space and to other planet we will take life with us.

How will life evolve in these new environments?

- Low or no gravity
- Cosmic radiation

How will human pathogens evolve?